U.S. Department of Agriculture Agricultural Research Service
• February 1984

Agricultural Research

Ag Research—
Never a Breed Apart

Agricultural research is one of the oldest sciences, and yet it remains at the cutting edge, continually producing fundamental information about every link in the food chain—man, animal, plant, microorganism—and their environment. And just as each link affects the others, the findings of agricultural research cut across the biological, chemical, and physical sciences.

A case in point is the work of ARS's *Scientist of the Year* for 1983. Ronald L. Horst is an animal physiologist at the National Animal Disease Center in Ames, Iowa. His special interest is vitamin D, which regulates the amount of calcium and phosphorus in the blood of humans and animals. A ready supply of calcium is necessary for normal bone formation, muscle contraction, nerve conduction, and a host of other physiological processes.

In order to study mineral metabolism in animals, Horst developed a quick but highly sensitive technique for measuring vitamin D in its plant form (D_2), its animal form (D_3), and its numerous biologically active forms in blood, milk, and tissue. Prior to this, concentrations of vitamin D had to be estimated through crude, time-consuming bioassays which understandably, precluded much research in this area.

Now, with the help of high-pressure liquid chromatography, scientists can trace the vitamin's movement through the body, determine its biologically active forms, measure how fast it is utilized, and ultimately understand, at the molecular level, how it functions or malfunctions in human and animal systems.

The application of these techniques has already had a significant impact on the research approach to diseases of mineral metabolism in animals and humans. Horst, together with his colleagues at the National Animal Disease Center and non-ARS collaborators in the fields of human and animal health, has unearthed a number of important findings among which are:

- Proper dosage of vitamin D is critical in treating milk fever—a disease of dairy cattle that annually costs producers between $10 and $20 million. Improper timing or dosage of both the biologically active form of vitamin D and some of the newer synthetic forms can be toxic and worsen the disease. Furthermore, we now know that rations low in calcium and phosphorus are safe and effective in preventing milk fever, and we know why.
- Cattle, swine, and rats preferentially metabolize vitamin D_3 over D_2, which may account for the fact that D_2 is less toxic to animals. The finding has practical application because feed suppliers supplement feed with vitamin D_3.
- Diabetic humans and people with malignancies have low blood levels of the biologically active form of vitamin D. In diabetics, this probably accounts for their higher incidence of bone disease and provides a better basis for treatment.
- Hospital patients who receive all of their nutrients through intravenous solutions are unable to synthesize biologically active vitamin D. This could explain the development of bone diseases in these patients and will, no doubt, produce adjustments in their therapy.
- Patients who have primary hyperparathyroidism (excess parathyroid hormone) can be separated into two subgroups by the concentrations of biologically active forms of vitamin D in their blood. The two subgroups must be treated differently if therapy is to be effective.

The study of animals, plants, and insects has and will continue to produce many scientific revolutions. The science of genetics was born with the pea plant and grew up with the fruit fly. Population genetics got its start with modern theories of plant and animal breeding developed by USDA scientists in the early 1920's, and more recently, jumping genes were discovered in maize. In the future, a full understanding of photosynthesis will enable mankind to convert everlasting and extraterrestrial energy from the sun into chemical, electrical, and mechanical energy here on earth with greater efficiency and less waste than with fossil or nuclear energy.

Agricultural research is, at the same time, down to earth and lofty. Last year, routine experiments on the volatility of pesticides from cropland conducted at Beltsville, Md., produced evidence that questions a 63-year-old theory on the movement of gases in our atmosphere. The revamped theory, which incorporates the principles of molecular diffusion with those of atmospheric dispersion, has major implications for the fields of micrometeorology, atmospheric chemistry, and air pollution.

A method for encapsulating drugs in red blood cells (see page 4) developed by an ARS scientist in Kerrville, Tex., may someday revolutionize the way shortlived or toxic drugs are administered to humans.

Far from being a breed apart, agricultural researchers are right in the thick of science.

Terry B. Kinney, Jr.
ARS Administrator

Contents

Agricultural Research
Vol. 32, No. 6
February 1984

Editor: Jean M. Rawson
Assistant Editor: Judith L. McBride
Photography Editor: Robert C. Bjork
Art Director: Deborah Shelton

Agricultural Research is published 10 times per year by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, D.C. 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through March 31, 1987. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by month and photo number.

Reference to commercial products and services is made with the understanding that no discrimination is intended and no endorsement by the Department of Agriculture is implied.

Magazine inquiries should be addressed to: The Editor, Information Staff, Room 318, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, Md. 20705. Telephone: (301) 344-3280. When writing to request address changes or deletions, please include a recent address label.

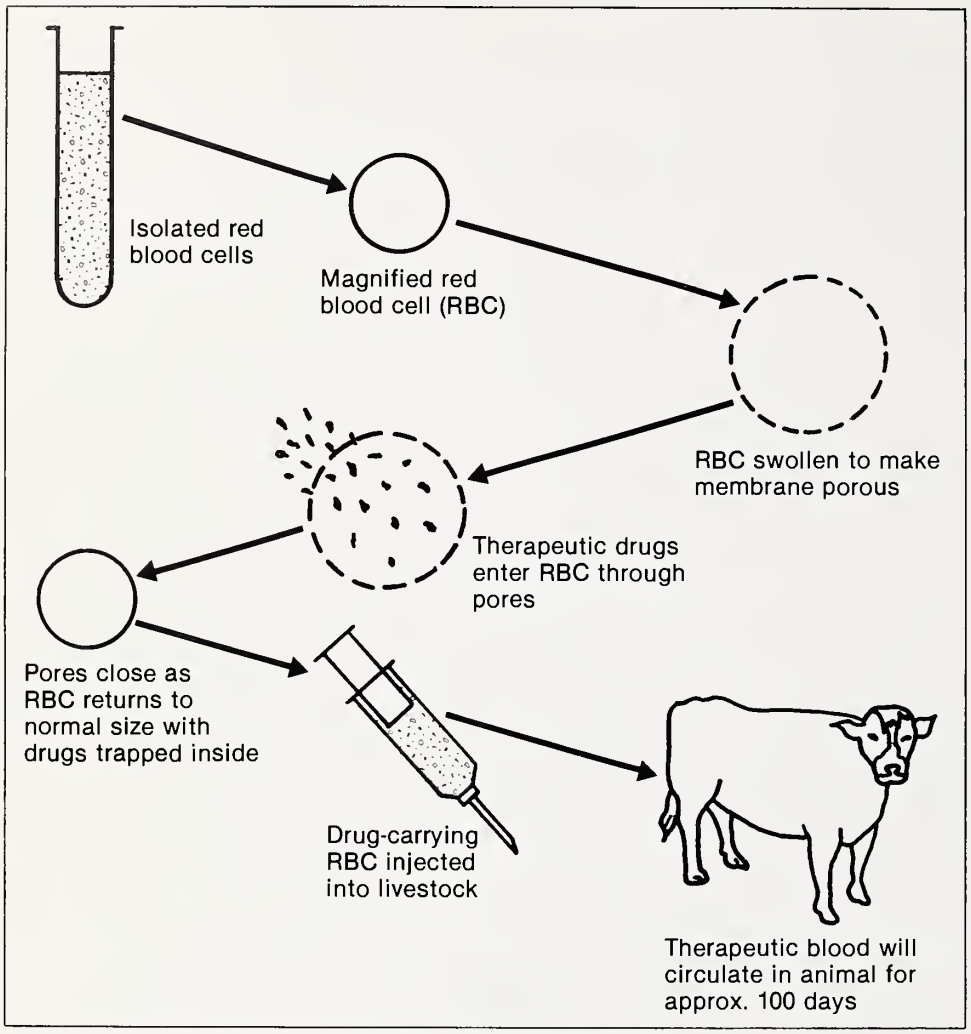
John R. Block, Secretary
U.S. Department of Agriculture

Orville G. Bentley
Assistant Secretary
Science and Education

Terry B. Kinney, Jr.
Administrator
Agricultural Research Service

Cover: Barley yellow dwarf, a viral disease of small grains, is on the increase around the country. ARS and state scientists at several locations are coordinating research efforts to combat the yield-robbing disease. At Purdue University, W. Lafayette, Ind., agronomist John J. Roberts checks fall-seeded wheat that has been artificially infested by BYD-carrying aphids. Article begins on page 8. (1183X1631-16)

RBC's--Natural Time-Release Capsules



Red blood cells (RBC) may provide an ideal delivery system for many veterinary medications and for human medications as well. (PN-7084)

Red blood cells may someday be used to store and circulate medical drugs for slow release to the bloodstream so the body retains the drug longer than it does regular injections.

ARS biochemist John DeLoach at the U.S. Livestock Insects Laboratory, Kerrville, Tex., developed the slow-release process using the red blood cells of several animals as models for the human system.

After 5 years and more than 900 experiments using 25 drugs, DeLoach says he and colleagues have found "several advantages to using red blood cells to encapsulate drugs—especially those that degrade quickly or are highly toxic."

Encapsulating cytarabine, a shortlived cancer drug, within canine red blood cells, sustained its therapeutic value in dogs for 10 days compared to 2 hours for conventional free injection of the same dose, he says. The drug slowly diffuses across the cells' membranes. Working with dogs, DeLoach established that repeated administrations did not cause any change in the survival of cells.

The process also has potential to lower drug dosage. In one series of tests with 12 Hereford heifers, an encapsulated drug at one-tenth the dosage of the intramuscularly administered drug protected the heifers for at least 35 days against a lethal infection of Texas cattle fever. The fever is caused by the tick-transmitted protozoan *Babesia bovis*.

So far, DeLoach has successfully tested his process with cattle, horses, pigs, and dogs. And other scientists throughout the world (in Canada, Australia, Germany, England, Argentina, and Japan) are finding even broader applications in their experimental work. They have encapsulated drugs and enzymes to successfully treat rheumatoid arthritis in rats, diabetes and leukemia in mice, and leishmaniasis in hamsters; to replace enzymes in humans; and to protect livestock from blood-feeding parasites.

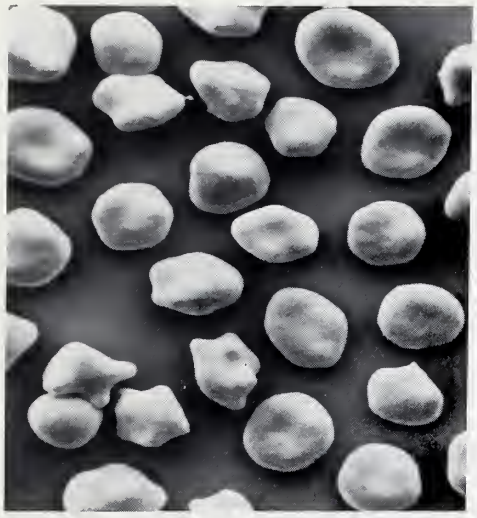
Moreover, drugs encapsulated within red blood cells can be selectively targeted to specific organs, notes DeLoach. By chemically altering the outer surface of red blood cells, one can keep them confined in the liver or spleen. This may be useful for treating diseases caused by parasites of these organs.

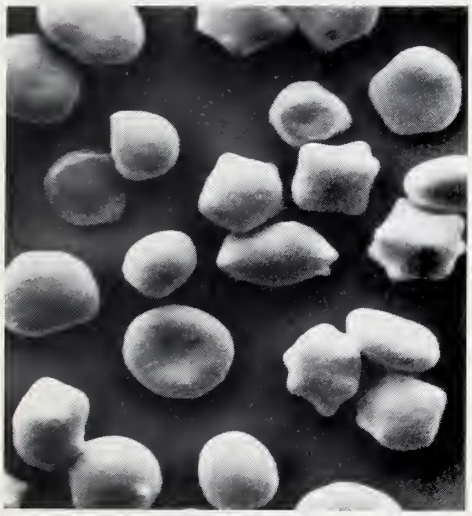
DeLoach said he was attracted to red blood cells as a slow-release method of administering drugs because many drugs are shortlived. "Soon after drugs are injected they are rapidly destroyed by animal and human systems or rapidly excreted from them. In either case, the drug is soon gone from where you want it," he says.

Instead, DeLoach's system converts red blood cells into "storage depots" that protect the drug from quick destruction and elimination. "The drug remains where we want it, doing the job, for a much longer period of time than it would if it were freely injected," he says.

Today, pharmacology is trying to improve on the mode of delivery of the thousands of drugs already available, mainly because developing new drugs is prohibitively expensive. The Pharmaceutical Manufacturers Association estimates that it now takes about $85 million and 10 years from the time a drug is discovered until it is marketed in the United States.

Many antibiotics can also be administered via carrier red blood cells, says DeLoach. However, some, like tetracycline, are not appropriate for this process. "Tetracycline diffuses across the red blood cell membrane so fast that encapsulation is of no value for slow release."





Scanning electron micrographs reveal no difference in size or shape of regular red blood cells (above, PN-7082) compared with those containing therapeutic drugs (below, PN-7083). Micrographs by Shirlee Meola, ARS, College Station, Tex.

ARS biochemist John DeLoach transfers blood from a steer into a dialysis bag in which the red blood cells will swell until their membranes develop microscopic pores large enough to allow the entry of therapeutic drugs. (1283X1668-23)

DeLoach conceived the idea to encapsulate drugs and pesticides in the red blood cells of cattle in 1977. He joined ARS's Veterinary Toxicology and Entomology Laboratory, College Station, Tex., in 1978 to pursue this research. He cooperated with scientists at Texas A & M veterinary school to develop a technique that allowed preparation of large quantities of blood cells for encapsulating drugs.

The process works by taking blood from an animal and isolating the red blood cells. Then the cells are placed in a dialysis bag where they are made to swell until microscopic pores develop within the cells' membranes.

At this point, the red blood cells are removed from the bag and mixed with a drug, DeLoach says. When the salt concentration of the cells is restored, the cells shrink to normal size. The small cell pores then close, trapping the drug inside the cells, he says.

The cells containing the drug can be remixed with whole blood and injected back into the animal where they will circulate freely and maintain a therapeutic drug level for days or even weeks, DeLoach explains.

Bovine red blood cells can be safely stored in a protein-free medium at 4°C for 20–25 days. "If the system works for bovine cells," says DeLoach, "it should work for the less fragile human or canine blood cells."

Although DeLoach began his research using bovine cells, he found that canine metabolisms more closely resembled humans'. Dogs, in addition to being smaller and less expensive than cattle to test, contract several diseases common to humans.

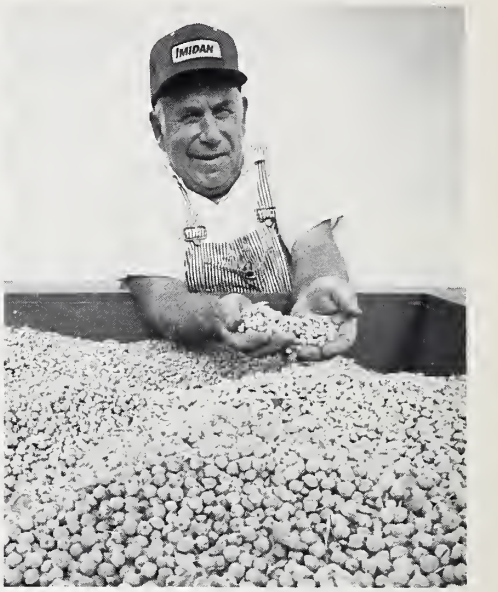
According to DeLoach, the process, apparatus, and application of his research have already been patented. All that remains is for the U.S. Department of Commerce to work out the details of licensing the patents to industry.

In both humans and animals, he says, "red blood cells may someday be used routinely to carry medications that are either highly toxic or have a short useful life in the body. Then we will be able to sustain optimum levels of such drugs for weeks at a time—without the bother of frequent injections."

John DeLoach is located at the U.S. Livestock Insects Laboratory, P.O. Box 232, Kerrville, Tex. 78028. —**Hank Becker and Bennett Carriere** ■

Garbanzos on the Palouse

ARS plant geneticist Frederick J. Muehlbauer (left) and University of Idaho plant geneticist Dick L. Auld (right) inspect a bumper crop of harvest-ready chickpeas on the farm of cooperator Sanford Evans near Genesee, Idaho. (0983X1288-11A)



Evans checks quality of his 1983 chickpea harvest which weighed in at 2,500 to 2,600 pounds per acre. (0983X1286-23)

It is almost difficult these days to enter a restaurant without seeing a salad bar, and where one sees a salad bar one generally sees garbanzos. Their popularity underscores the economic significance of the discovery by ARS and state researchers that the dryland grain regions of the Pacific Northwest are splendidly suited for garbanzo production.

Garbanzo is the popular name for the chickpea seed—a large, cream-colored legume, high in protein and used throughout the world in salads, bean dips, soups, and curries. Domestic production today is centered in California on about 6,000 acres, but two diseases, Fusarium wilt and root rot, limit yields there to 700 to 800 pounds per acre—far below potential yields.

To meet consumer demand, the United States currently imports as much as $12 million worth of garbanzos each year, mostly from Mexico. A rising domestic market will drive this figure upward unless production in the United States is dramatically increased.

Researchers with ARS, Washington State University at Pullman, and the University of Idaho at Moscow have found that chickpeas grown in the Palouse area of eastern Washington and northern Idaho yield close to 2,000 pounds per acre.

Severe erosion problems in the richly fertile and productive Palouse (see *Agricultural Research,* Oct. 1979, p. 4) call for a legume to rotate with wheat. Crops used in the rotation have long included dry peas and lentils, but diminishing economic returns, disease, and insect problems have caused a decline in the area's production. The chickpea, with comparable yields to dry peas and lentils and nearly four times the market value, is a handsome replacement candidate.

The chickpea's potential as a cash crop for the Palouse was first studied in the mid-1970's by ARS agronomist V. E. Wilson (retired) and since 1979 by ARS plant geneticist Frederick J. Muehlbauer. He says that better methods of mechanically seeding the legume are needed for large-scale commercial production. Drills used for seeding cereal grain damage chickpea seed, which results in poor plant establishment.

"Modifying existing drills and breeding more durable seeds are two promising approaches to solving this problem," says Muehlbauer.

A collection of chickpea germplasm containing over 3,400 accessions from all over the world is being maintained at ARS' Western Regional Plant Introduction Station in Pullman. Working with this germplasm to determine disease susceptibility and possible methods of control is ARS plant pathologist Walter J. Kaiser, one of the persons responsible for the original introduction of chickpeas into the United States.

Says Kaiser, "The major diseases affecting chickpeas in the Palouse region are damping-off, caused by the soilborne fungus *Pythium,* and virus diseases: particularly, alfalfa mosaic, pea enation mosaic, and pea streak."

Kaiser has shown that damping-off can be controlled by treating seeds with fungicides such as captan and metalaxyl. He is also hoping to find sources of disease resistance in the germplasm collection.

Growers in the Palouse have already expressed interest in chickpea production, and a few commercial plantings have been undertaken, amounting to about 3,000 acres in 1983.

Frederick J. Muehlbauer is located in Room 213-A, and Walter J. Kaiser in Room 59-A, Johnson Hall, Washington State University, Pullman, WA 99164.
—Lynn Yarris, Oakland, Calif. ■

Finding a Cure for Saline Seeps

Farming and several other land-use practices have accidentally created saline seeps on an estimated 2 million acres of dryland in the States of Montana, North Dakota, South Dakota, and the Canadian provinces of Alberta, Saskatchewan, and Manitoba. Seeps are also appearing in Oklahoma and Texas. Where they appear, crop production is wiped out or significantly reduced.

Sale seeps develop in areas where the surface material is glacial till underlain by marine shale or other layers of impermeable or barely permeable material. Both strata contain large amounts of magnesium, sodium, and calcium salts.

Excess precipitation picks up these salts as it moves down through the soil. This salty water—often as salty as the ocean—eventually hits the impermeable layers, and then moves sideways or downslope, emerging on farmers' fields. When the water evaporates, it leaves behind the salt.

After studying the problem for 10 years, ARS soil scientists Paul L. Brown, Bozeman, Mont., and Ardell D. Halvorson, now at Akron, Colo., recommend seeding alfalfa—a perennial plant that consumes large amounts of water with its deep roots—on areas where seeps are about to form or where they are rapidly expanding.

Contrary to an earlier practice of seeding alfalfa around the seep perimeter, Brown says the only effective way to seed is in recharge areas, where the excess precipitation collects—often with 2,000 feet upslope.

Locating recharge areas is often the hardest step in reclamation. Currently, a nine-county area in north-central Montana is getting help from the State-funded Triangle Conservation District, which is cooperating with the USDA's Soil Conservation Service. So far, more than 200 farmers and ranchers have used this service.

"Farmers and ranchers who do not use alfalfa hay might consider seeding grasses which have proven effective in areas where the impermeable layer is relatively close to the surface—6 to 12 feet. Grasses are easier to seed, fairly easy to manage, and can be as effective as alfalfa if the seep is not too severe," says Brown.

Another of the scientists proposals is to abandon the fallow cropping practice because it is particularly conducive to seep formation and expansion. Fields are cropped one year then left idle the next year so that precipitation will be saved to better insure an adequate moisture supply for the succeeding crop. However, after many years of alternate cropping, much water has accumulated below the plant root zone.

The researchers recommend a flexible system where farmers plant whenever the soil moisture, combined with the probability of additional precipitation, equals that year's crop reimbursement.

"Again, there will be reluctance to convert to flexible cropping because management practices will have to change. It is more difficult to control weeds an diseases if fields are cropped annually, and more labor and machinery will be required in some cases. On the other hand, farmers have found that annual cropping produces more income," says Brown.

Brown studied an 80-acre field on the Norris Hanford ranch near Fort Benton, Mont., that in 1971 had seepage outbreaks totaling 10 acres. He recommended seeding the entire field to alfalfa that fall. After being in alfala for 6 years, the seep area's water table had dropped to 10 feet below the surface, fromt he previous 1 foot, and to 28 feet in the recharge area, from the previous 19 feet.

The following year, the area was planted to winter wheat and yields on the formerly nonproductive saline area were 70 percent of those on the rest of the field. After 3 ;years, barley yields were equal in the saline areas to the rest of the field. Natural precipitation had removed the salt from the upper soil profile.

"Examples of reclamation are impressive," says Brown, "but data from the Hanford farm indicate that saline seeps would reappear if the crop-fallow system were to continue."

One more solution, according to Brown, is to improve drainage on certain recharge areas. Shallow ditches, minor land leveling, or contouring often is all that is needed to divert excess water from the recharge area.

Mike Linsenbigler (left) of USDA's Soil Conservation Service helps a Montana landowner monitor groundwater levels beneath a saline seep. After years of rising to create the seep, the water table has now begun to drop thanks to nearby plantings of alfalfa. (0883X978-8A)

Brown and Halvorson cooperated with scientists at ARS' Northern Great Plains Research Laboratory, Mandan, N. Dak., and research and extension personnel from Alberta and Saskatchewan. The Montana State University Agricultural Experiment Station also provided support.

Paul L. Brown is located at the Plant and Soil Science Dept., Montana State University, Boxeman, Mont. 59717.—**Dennis Senft,** Okland, Calif. ■

Barley Yellow Dwarf Commands Attention

Plant pathologist Henryk Jedlinski studies how oats respond to BYD infection. Oat plants on left reacted severely after simultaneous infection by two BYD strains. Plants on right were infected with one BYD strain and show mild reaction. These experiments show that infection involving two or more BYD strains produce a synergistic effect: the disease is more severe than if only a single strain were involved. (1183X1639-28A)

A complex virus disease affecting small grains is on the upswing in various parts of the United States. In 1981 and 1982, infections in Midwest small grains nurseries were nearly as serious as an epidemic in 1959, ARS scientists observe.

Fortunately, producers of small grains can avoid disastrous yield losses from the disease, called barley yellow dwarf (BYD) or red leaf, by planting tolerant grain varieties. But even with today's improved varieties, "We probably lose at least 5 percent of our wheat and 10 percent of our oats in a normal year," says ARS agronomist John J. Roberts, a member of a small grains research team at West Lafayette, Ind.

BYD is caused by one or more viruses called luteoviruses that are transmitted from plant to plant by aphids. Similar luteovirus diseases in crops other than small grains include beet western yellows and soybean dwarf. Luteoviruses are thought by some scientists to be so closely related that they form one interacting system in nature, and therefore concepts of separate diseases may be too narrow.

The severity of BYD, says ARS entomologist John E. Foster, also at West Lafayette, depends on complex interactions among aphids, viruses, various plant species, and environmental conditions.

Roberts estimates that yield losses in 1982 from recently developed grain varieties and germplasm lines in the Purdue University nursery at West Lafayette were about half as great as losses from varieties developed before the 1959 epidemic. During that epidimic in Illinois, for example, BYD depressed oat yields by 90 to 100 percent in some parts of the state. Total Illinois yield declined by about 28 percent, representing about a $24 million loss. Other North Central states experienced similar damage.

Only in recent years have scientists become aware of the yield-robbing effect of BYD in wheat because symptoms are hardly noticeable at a distance. Faint yellowish-green blotches on the leaves enlarge and turn various shades of red, purple, brown, and yellow orange depending on genetics of the plant.

While researchers have achieved successes in breeding crop varieties that resist the disease, Roberts notes that serious outbreaks of BYD have recently become prevalent in the Midwest each year. BYD is on the increase also in the Southeast, where wheat acreage has increased dramatically, and in the Pacific Northwest where changes in irrigation and cropping practices have increased the abundance of aphid vectors.

In 1980, Washington State University entomologist Keith S. Pike and plant pathologist Steven D. Wyatt found that aphids had transmitted BYD virus (BYDV) to about 80 percent of the 150,000 acres of irrigated corn in the Columbia Basin. Although corn harbors the virus, scientists have no evidence that corn yields are affected.

Foster and Purdue University plant pathologist Richard M. Lister are examining corn and other grass plants as potential bridging hosts for the spread of aphids and viruses to fall-planted wheat in the Midwest.

Lister and Foster are using a test called ELISA (enzyme-linked immunosorbent assay) to detect and measure antigens produced by specific luteoviruses. They hope to learn which BYDV isolates may combine to be synergistic—cause the severity of infection to be greater than the expected combined effects of individual virus strains. And they may be able to improve their basis for breeding new resistant varieties by comparing the viruses harbored by resistant and susceptible varieties of wheat, oats, and barley.

They also hope to learn whether plants infested by many aphids have a more severe case of BYD than plants fed on by a few aphids. Could identification of plants that aphids prefer not to feed upon increase success in breeding varieties that are less threatened by BYD? So far, breeding for a minimum of BYD symptoms has been the only successful approach, but the researchers are not ruling out nonpreference by insects.

Foster is also working with Purdue University wheat breeder Herb W. Ohm and plant pathologist Greg E. Shaner to develop small grain varieties with resistance to BYD.

In the course of research on resistance of small grain crops to diseases and insects, ARS and Purdue University scientists have bred wheat varieties that are now grown on more than 75 percent of the soft red winter wheat acreage in the United States. One of their most recently released BYD-resistant wheat varieties, 'Caldwell', was named after plant pathologist Ralph M. Caldwell, a member of the team from 1931 to 1971.

In 1980, the team released 'Elmo', a BYD-resistant germplasm line of wheat, and in 1981 they released 'Porter', a BYD-resistant variety of spring oats.

At the University of Illinois, Urbana, pioneering research begun in the late 1950's by ARS and state scientists is also paying off. In 1952, several experimental lines of oats showed outstanding resistance, as did 'Ogle' oats, an Illinois-developed variety with wide geographical adaptation and high-yielding capacity.

As new races, or isolates, of BYDV appear, researchers may be kept busy developing new germplasm and resistant varieties. However, ARS plant pathologist Henryk Jedlinski sees breeding for BYD resistance as only part of a big picture. For example, the

Top: In a University of Illinois test plot, experimental BYD-resistant oat lines (background) prosper though planted next to highly susceptible accessions from the U.S. Small Grains Collection at Beltsville, Md. Illinois-developed oat varieties are among the most BYD-resistant and high-yielding ever released. (PN-7088)

Above: Jedlinski inspects colonies of BYD-transmitting aphids maintained under controlled environmental conditions in growth chambers. He will use the aphids to transmit BYD virus in research aimed at developing resistant oat varieties. (1183X1641-24A)

Wheat heads are prepared for crossbreeding by graduate student Fred E. Maas at Purdue University. He will transfer sources of BYD resistance from new wheat introductions to current breeding lines. (1183X1634-22A)

In the ELISA test, Purdue University plant pathologist Richard M. Lister prepares microplate test wells to trap and identify BYD virus. If the virus is present, enzymatic antibodies will cause an enzyme substrate to turn yellow. (1183X1637-22A)

ability of plants to resist BYD may be lessened by rusts and smuts.

At Brookings, S. Dak., ARS entomologist Robert W. Kieckhefer is researching another part of the big picture. He is studying the effectiveness of several groups of insect predators on the regulation of aphid populations, especially early in the growing season when aphid numbers are low. That is when predation could most dramatically inhibit population increases and reduce disease transmission.

ARS scientists at Frederick, Md., are working with researchers at Pennsylvania State University, University Park, to develop a system for monitoring movement of aphids. Information they obtain by using suction trap collectors to capture the aphids may become a component in an early warning detection system for growers. They will also compile information on which species of aphids that move about locally or migrate from afar are carrying viruses that pose a hazard to crops.

ARS plant pathologist William F. Rochow, Ithaca, N.Y., is conducting studies on interactions between the virus and the salivary glands of aphids. Although his studies are basic, he suggests that learning the mechanisms by which specific aphids transmit, or fail to transmit, specific viruses could help scientists predict outbreaks of BYD.

During the past 20 years, Rochow has observed a gradual change in the predominating BYDV isolates in New York. The predominating isolate now is of a type called PAV rather than the earlier primary isolate called MAV that is transmitted as a single virus only by *Sitobion avenae*, commonly called English grain aphids.

With a little help, though, MAV can be transmitted by such other aphids as *Rhopalosiphum padi,* also known as padi aphids or oat bird cherry aphids. In the laboratory, Rochow has found that padi aphids can transmit MAV if plants are doubly infected with it and either of two "helper" viruses, RPV or PAV. The padi aphids can also transmit isolates SGV and RMV from plants infected with either of the same helper viruses. In turn, RMV is a helper virus in transmission of still another virus, RPV, by *Rhopalosiphum maidis,* or corn leaf aphids.

"Since we find doubly infected plants common in nature, we think this system of dependent transmission could be important in the field," says Rochow.

The two most notorious BYDV vectors in the Midwest are the padi aphid and the English grain aphid. Jedlinski has found, however, that BYDV may be transmitted to plants by any of at least 18 different aphids.

Padi aphids may pose a greater threat to oats than do English grain aphids, says Jedlinski. His studies showed padi aphids moved the virus from plant

Padi aphids on a wheat leaf. Only 1 to 2 mm in length, *Rhopalosiphum padi* is one of the most infamous transmitters of barley yellow dwarf. (1183X1636-14A)

All aphids have the same feeding mechanism: a long slender "trunk" called a proboscis with which they penetrate plant tissue. This English grain aphid probes the food-conducting tissues of wheat and oats that harbor BYD virus. The aphid thus spreads the virus from infected to non-infected plants. Scanning electron micrograph 200 times life-size. (PN-7086)

to plant more than twice as frequently as did English grain aphids. And after the virus-carrying padi aphids fed on oats, the disease developed in about 11 days—only two-thirds of the time it took the disease to develop on oats inoculated by English grain aphids.

Once a padi aphid feeds on even one infected plant, it may transmit BYDV to other plants for the rest of its life. Also, during its lifetime of about 1 month, the aphid may produce 40 to 100 young that will be around to transmit the disease.

Some kinds of aphids colonize on plant roots where they are difficult to detect. In 1982, Jedlinski found colonies on some diseased plants only after the plants had been brought to the laboratory and kept in cages for a while. He sent some of these aphids to taxonomist David Voegtlin of the Illinois Natural History Survey, Urbana, for identification. He also sent infected leaf samples to Purdue University where Lister will conduct identification tests on the virus isolates that these particular aphids carried.

"As we learn more about the biology and dynamics of aphid vector associations below the soil, we may be able to develop some effective BYD control measures based on integrated pest management," says Jedlinski.

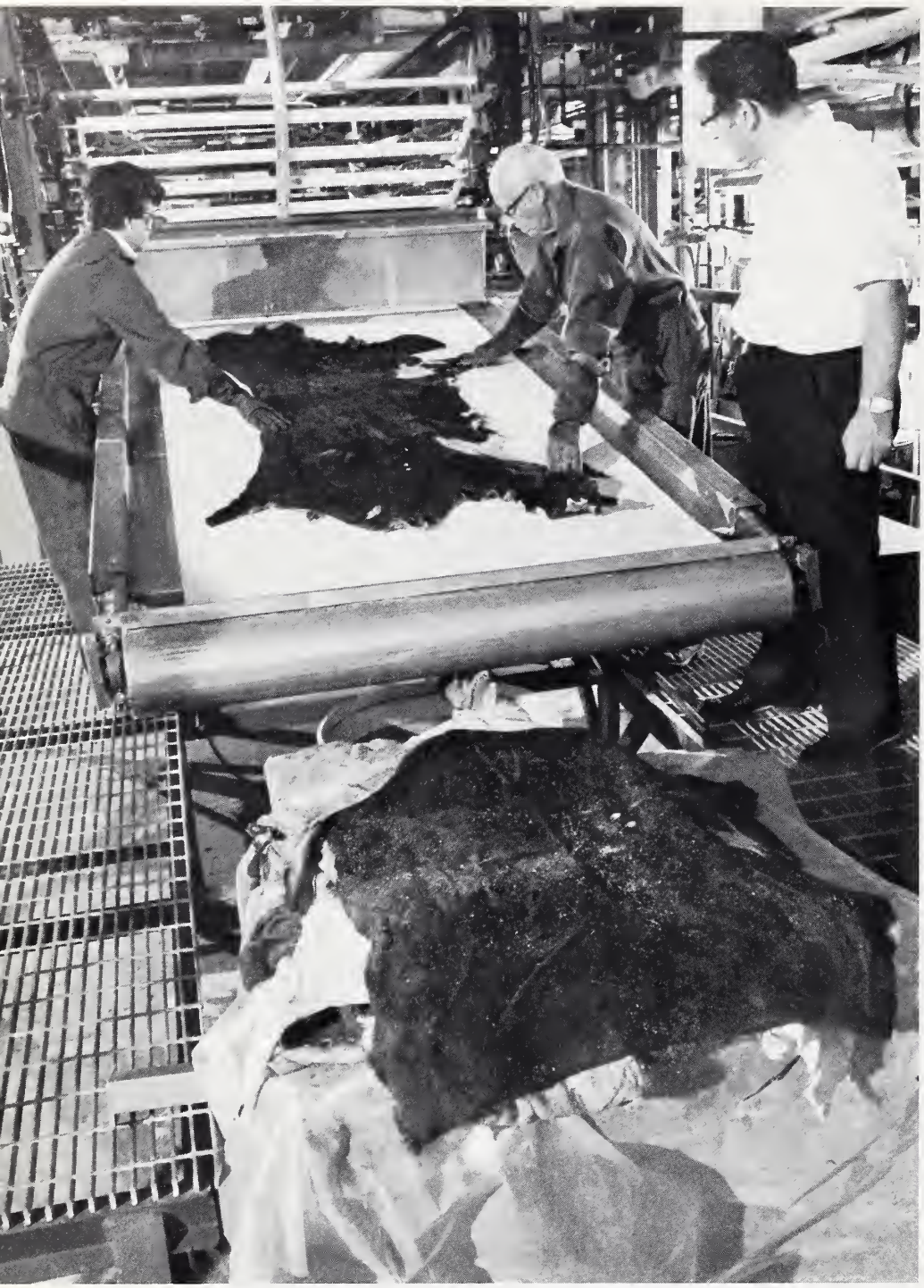
Extension advisors generally don't recommend spraying small grain crops with insecticides. Contact insecticides may not kill aphids that migrate to the field after spraying. Systemic insecticides in plants may agitate the aphids, increasing their mobility from plant to plant, and those sprayed plants that the insects feed on would not escape infection, Jedlinski says. Spraying may also kill ladybird beetles, parasitic wasps, and other biological control organisms.

The most severe outbreaks of BYD are normally found on oats. Extension advisors recommend these practices to minimize the threat:

- Plant oats early and fertilize according to soil tests;
- Avoid cropping systems that might allow excessive volunteer wheat and barley to grow near or with oats;
- Grow oat varieties that are tolerant to BYDV.

John E. Foster is located in Room 122, Entomology Hall, Purdue University, West Lafayette, Ind. 47907. —**Ben Hardin,** Peoria, Ill. ■

Americans Can Benefit From Tanning Their Own Hides



Chemical engineer Michael Komanowsky observes as acting research leader Dennis O'Brien and chemical engineering technician Ralph Bruch spread a cattlehide on the automatic feed conveyor. (0883W959-16A)

A 150-foot-long, two-story "continuous beamhouse processing" pilot plant at Wyndmoor, Pa., is clearly the biggest part of the ARS's Tannery of the 80's Project, both in size and importance. The project is an accelerated effort to upgrade tanning technology in the United States.

The ancient art of leathermaking is today an automated industry where methods have steadily improved to a high degree of sophistication. However, the preparation of hides for leathermaking has not kept pace, resulting in the export of hides and dollars. A primary reason is the uneven shape and irregular size of the raw material.

ARS engineers designed the experimental plant to clean up and automate cattlehide processing operations, which have remained virtually unchanged for centuries in the United States and abroad, according to James C. Craig, a leader of the project and chief of the Engineering Science Laboratory at the Eastern Regional Research Center in Wyndmoor.

"The idea," says Craig, "is to help U.S. tanners get away from laborious and inefficient leathermaking practices. Our studies show the continuous beamhouse plant to be highly cost-effective. Thus, the research is gaining the interest and cooperation of the domestic industry."

In contrast to foreign tanneries, the U.S. tanning industry has suffered declining profits in recent years. Over 50 percent of U.S. cattlehides are now exported for inexpensive processing abroad. Ironically, shoes and other leather products imported to the United States are often made from U.S. hides. In 1981, the net trade deficit between the value of exported hides and imported leather goods was $3–$5 billion.

The highly automated "continuous beamhouse process" could reverse the flow. It offers a technological edge that could once again make U.S. tanneries competitive for the 20 million U.S. hides sold abroad. The process was designed by mechanical engineer Wolfgang Heiland and chemical engineer Michael Komanowsky.

New Treatment for Sulfide-Laden Tannery Waste

Having passed through the first of three conveyors in the continuous beamhouse process, a hide with chemically loosened hair is now ready for the unhairing machine. Mechanical engineer Wolfgang Heiland operates the control panel for transferring hides from the first to the second conveyor. (0883W960-28)

Not quite ready for a purse or a pair of shoes, a sample of "crust" leather (finished leather minus topcoat) made from hides processed by the continuous beamhouse is inspected for quality by project leader James C. Craig, a chemical engineer. (0883W962-23A)

The process combines a unique automatic feeding device with conveyor systems that transport hides through soaking and chemical unhairing, followed by mechanical unhairing and fleshing, and on to an automatic hide-splitting system that produces hides of uniform thickness.

It is the cleanest, most self-contained hide processing operation yet invented, say Heiland and Komanowsky. It permits automatic measurement of hide area as well as visual inspection and grading while eliminating almost all hand labor.

The term "beamhouse" is a relic of yesteryear when hides were hand-treated on logs or beams. Today, the beamhouse operation includes most of the labor-intensive steps in hide processing. And, because it is done on a batch-by-batch basis, it consumes a great deal of water and generates large volumes of waste, causing a serious pollution problem.

The new technology offers tanners substantial savings in labor and in water. It also reduces pollution by using smaller amounts of processing chemicals. Despite the high value of hides, tanners have often been forced to operate well away from populated areas because of unpleasant odors and uncleanliness associated with some of the processes.

USDA scientists have been conducting research on hides and leather for over 40 years and have developed much of the current processing technology.

James C. Craig, Wolfgang Heiland, and Michael Komanowsky are located at the Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, Pa. 19118. —**Stephen Berberich,** Beltsville, Md. ■

Capitalizing on Darwin's "survival of the fittest" theory, ARS scientists have developed a new treatment for tannery wastes containing toxic sulfide. They isolated micro-organisms that actually thrive alongside sulfide compounds.

The discovery reversed a prevailing theory of industrial waste disposal: namely, that anaerobic micro-organisms cannot decompose organic waste in the presence of sulfides.

The new treatment, say the scientists, offers leather tanneries and other industries that generate high-sulfide waste, such as paper and pharmaceutical manufacturers, a cheaper way to meet 1985 federal water pollution guidelines.

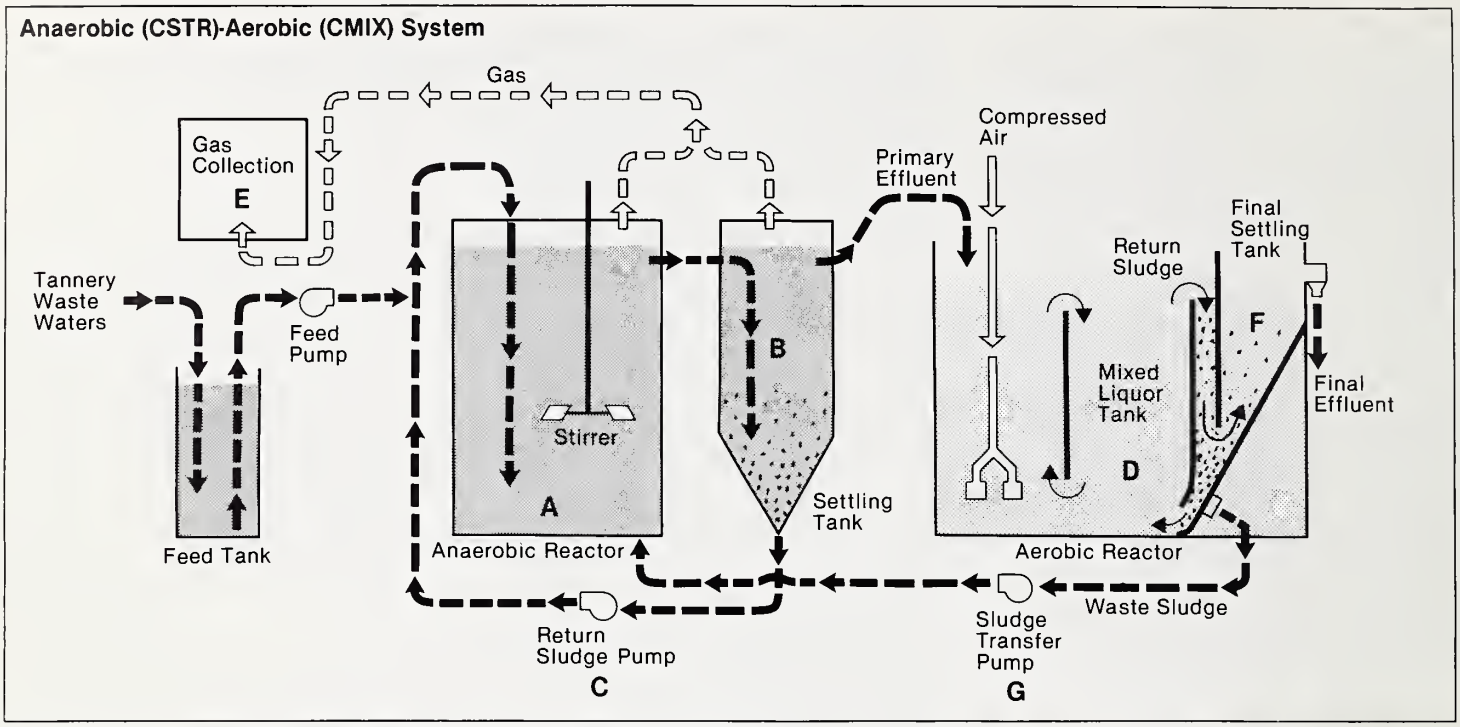
Moreover, the treatment could add to the profits of industries that discharge high amounts of biodegradable materials without sulfide compounds.

Research chemists David G. Bailey, Joseph E. Cooper, Joanna M. Moore, and Michael H. Tunick at the Eastern Regional Research Center (ERRC) developed the new system using an anaerobic (oxygen-free) reactor. They improved on the results of earlier research on anaerobic treatment of tannery waste done in collaboration with A. A. Friedman, a professor of civil engineering at Syracuse University.

In the latter treatments, the reactor went a step beyond expectations, according to Bailey, team leader for the research. As expected, the team found that their microbes could aggressively degrade a "diet" of tannery waste without the aid of oxygen as an energy source. However, somewhat unexpectedly, they also found that their microbes could degrade the tannery waste in spite of the high levels of sulfide. The scientists had expected that the waste would have to be pretreated to remove sulfides.

Sulfide is used by tanners to unhair hides. Resulting high-sulfide waste effluent can be very toxic to natural environments, Bailey says. Removing sulfides in industrial wastes adds considerable expense to waste treatement.

The team began by placing a batch of sewage sludge from a municipal plant into their reactor with the idea of altering conditions so as to encourage



The anaerobic/aerobic system operates as a self-contained ecological system in which microbes digest tannery wastes. Biodegradation begins after tannery wastes are pumped into the anaerobic reactor (A) containing biosludge. After treated wastes overflow into the settling tank (B), the microbes are recycled (C) as primary effluent moves on to the aerobic reactor (D). Meanwhile, methane generated during the anaerobic process is collected for measurement (E). In the aerobic reactor, compessed air supplies oxygen for the microbes and suspends them as they absorb remaining wastes. As the effluent drains into the final settling tank (F), the microbes settle to the bottom and are recirculated in the aerobic reactor or recycled to the anaerobic reactor for further digestion (G). The final effluent is then ready for river disposal. (PN-7087)

only sulfide-tolerant, anaerobic species to survive. Tens of thousands of microbial species in the sludge acted as a starter culture for the process.

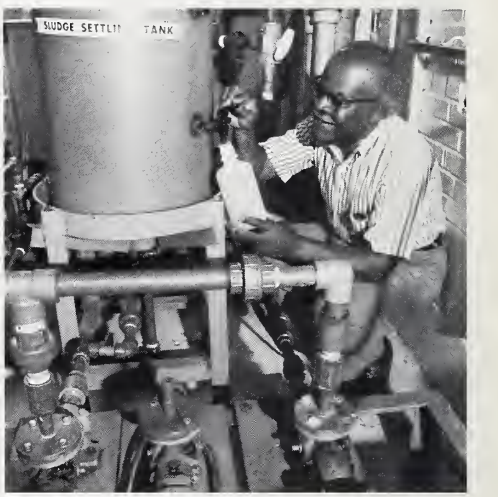
First, the researchers fed their culture a mixture of typical tannery waste and added glucose for an energy source. They slowly reduced the percentage of glucose in subsequent "feedings." As they introduced more and more tannery waste, sulfide-tolerant anaerobic microbes survived, multiplied, and eventually dominated the microflora in the reactor. At completion of the experiment, the anaerobic reactor was transforming sulfide-laden tannery waste into inert matter, methane, and material (including sulfide) readily digested in an aerobic polishing step.

An industrial scale-up of the anaerobic reactor could digest between 60 and 70 percent of tannery pollutants, says Bailey. He explains that the system would still require an additional aerobic treatment to scrub-up the operation. However, he emphasizes, "We have overcome our greatest obstacle: namely, sulfide inhibition of the microflora. Now, sulfide-containing industrial wastes which do not contain other toxic components can probably be treated economically in the future."

The scientists scaled up their laboratory experiment to a pilot plant last year and are conducting tests.

The primary achievement of the ERRC team is that their new anaerobic treatment system is potentially less expensive to construct and operate than the larger aerobic systems that are now commonly used to treat tannery waste. Aerobic systems—those utilizing oxygen-dependent species of microbes—can handle only low-concentration waste and therefore require larger volume reactors than corresponding anaerobic units. There is also the added expense of aerating the system.

In accordance with the 1977 Clean Water Act, the U.S. Environmental Protection Agency's Effluent Limitation Guidelines for Leather Tanning and Finishing Industries sets limits on pollutants discharged into streams and navigable waters by 1985.



Research chemist Joseph Cooper collects biosludge from a settling tank. He will then examine it under microscope to determine the efficacy of microbes in the anaerobic treatment. (0883W956-21)

David G. Bailey, Joseph E. Cooper, Joanna M. Moore, and Michael H. Tunick are with the Hide Processing Research Laboratory, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, Pa. 19118.

—**Stephen Berberich,** Beltsville, Md. ■

Don't Blame Cattle

Grazing cattle pose little if any water quality hazard in terms of nutrient pollution, concluded ARS and other researchers after a 3-year cooperative study sponsored jointly by the USDA and the U.S. Environmental Protection Agency.

Preserving water quality demands identification of the pollution sources. Nutrients such as nitrogen and phosphorus contained in runoff from agricultural lands are a known source. Of special concern has been the quality of water receiving runoff from land where cattle have grazed.

Researchers with ARS, Washington State University, and the University of Idaho measured and compared the amount of nutrients in runoff from a nongrazed watershed with those from a conventionally managed, cattle-grazed watershed in a typical high-rainfall area of the Pacific Northwest.

They found that although nitrogen and phosphorus levels in runoff from the grazed watershed were higher, the quantities should not present a pollution hazard to receiving waters.

Representing ARS in the study were microbiologist Lloyd F. Elliott and engineer Keith E. Saxton. Both can be reached at Room 215, Johnson Hall, Washington State University, Pullman, Wash. 99164. —**Lynn Yarris,** Oakland, Calif. ■

Poor Man's Marker

ARS researchers have designed a do-it-yourself spray marker that is a fraction of the cost of commercial spray markers. Markers are used to signal what areas of a field have been sprayed with pesticides so as to avoid missing or overlapping.

Called the Poor Man's Marker, the new device uses ordinary shaving cream as marking material and can be easily constructed with about $3 worth of plastic pipe and tubing. It was designed by soil scientist Truman W. Massee and technician Harold O. Waggoner, both with ARS at the Snake River Conservation Research Center, Kimberly, Idaho.

The "USDA Poor Man's Marker" is a do-it-yourself device for marking the edge of pesticide-sprayed areas with easy-to-see blobs of shaving cream. A pull string attached to the tractor seat activates a trigger on the shaving cream container. (0782X759-7)

The two most commonly used commercial spray markers dispense either a red dye or foam from the ends of sprayer booms by means of separate motor-driven pumps. Both cost over $1,000 which generally discourages most growers and even many custom applicators from using any markers at all. Instead, they rely on landmarks or tractor wheel tracks for guidance—a haphazard method not always accurate.

Essentially, the Poor Man's Marker is a can of shaving cream inside a jacket of plastic pipe mounted on the end of a spray boom and capped with a trigger mechanism connected by cord to the tractor. By tugging on the cord, the tractor operator can dispense globs of readily visible cream to clearly mark the edge of the spray's swath.

Says Massee, "There are only about 60 seconds of steady flow in each full can of shaving cream, so with half-second tugs on the cord a grower should be able to get about 120 good globs per can. With markers at both ends of a boom, that is a total of about 240 globs which should cover about 25 acres if the cord is tugged every 200 feet."

The cost in shaving cream is around 10 cents an acre, estimates Massee who says he got the idea from children spraying cream at Halloween and from the tradition of spraying the honeymoon vehicles of newlyweds.

Instructions for constructing the Poor Man's Marker can be obtained by writing to Truman W. Massee at the Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341. —**Lynn Yarris,** Oakland, Calif. ■

New Spreader Works "With the Grain"

The way in which grain is distributed in the storage bin can affect its quality. Fine material, such as grain dust and broken kernels, tends to accumulate under the grain stream in the center of the bin, impeding airflow which, in turn, produces uneven drying and the potential for hot spots in the grain. It also increases the risk of insect and fungal infestations.

But a self-propelled, four-trough grain spreader developed at ARS' Grain Marketing Research Laboratory in

Manhattan, Kans., can alleviate these problems. The spreader significantly improved the distribution of fine material in corn and produced a nearly level grain surface, according to Cheng S. Chang, an agricultural engineer and leader of the team who developed the spreader.

The team compared its four-trough spreader with a commercial two-trough spreader and with no spreader in a test bin measuring 21 feet in diameter with 18-foot sidewalls. The four-trough spreader produced a nearly level surface without hand labor when deflectors at the end of each trough were adjusted so that part of the grain was directed toward the center of the bin and part toward the wall. With the two-trough spreader, grain near the bin wall was much deeper than at the center. Without a spreader, the grain piled up in the center of the bin 2.5 times higher than at the walls.

"By using the energy of the falling grain to power our spreader, we saved electricity and eliminated electrical wiring and the associated hazards," Chang says.

Dust concentrations in the air were higher when spreaders were used, but the four-trough spreader did not cause significant grain damage. The two-trough spreader caused more grain damage than the other systems.

Working with Chang were engineering technician Larry E. Shackelford, chemical engineer Fang S. Lai, agricultural engineer Charles R. Martin, and chemist Byron S. Miller, now retired.

The scientists are located at the U.S. Grain Marketing Research Laboratory, 1515 College Ave., Manhattan, Kans. 66502. —**Ray Pierce,** Peoria, Ill. ■

The Orchard Rot-Water Connection

Surveys of commercial orchards show that root and crown rot occurs most frequently in orchards subject to poor soil water drainage and to periodic or repeated standing water around the trunks of trees.

In some cases the standing water may be due to the increased use of irrigation in fruit orchards. In other areas, root and crown rot reaches epidemic proportions following unusually high rainfall during late fall, winter, and early spring, according to ARS plant pathologist John Mircetich at Davis, Calif.

A few years ago Mircetich found that a group of soil-borne, water-mold fungi from the genus *Phytophthora* caused root and crown rot of deciduous fruit trees in California. Previously, the disease had been ascribed to various causes including other pathogens, "wet feet," or "sour sap."

Phytophthora can be introduced into healthy orchards by infected plant material, by infested soil on farm machinery, or by runoff water, says Mircetich. Once introduced, they can persist for a long time, making eradication extremely expensive and often impossible. Thus, he emphasizes, "all precautions should be taken to avoid the spread of these pathogens to healthy orchards."

In the long run, Mircetich recommends that resistant rootstock be planted where trees have died, on sites that have a history of *Phytophthora* root and crown rot, or on sites likely to be infected by the disease. "Use of resistant rootstock will minimize losses," he says.

Observations suggest marked difference in resistance of different rootstocks to certain *Phytophthora* species, but the more resistant rootstocks may not be resistant to all species known to cause root and crown rot.

Several fungicides have given encouraging results on the disease in cherry orchards, Mircetich says, but further testing over a longer period of time is necessary to properly assess their usefulness in orchards.

John Mircetich is located at Hutchison Hall, University of California, Davis, Calif. 96616. —**Paul Dean,** Oakland, Calif. ■